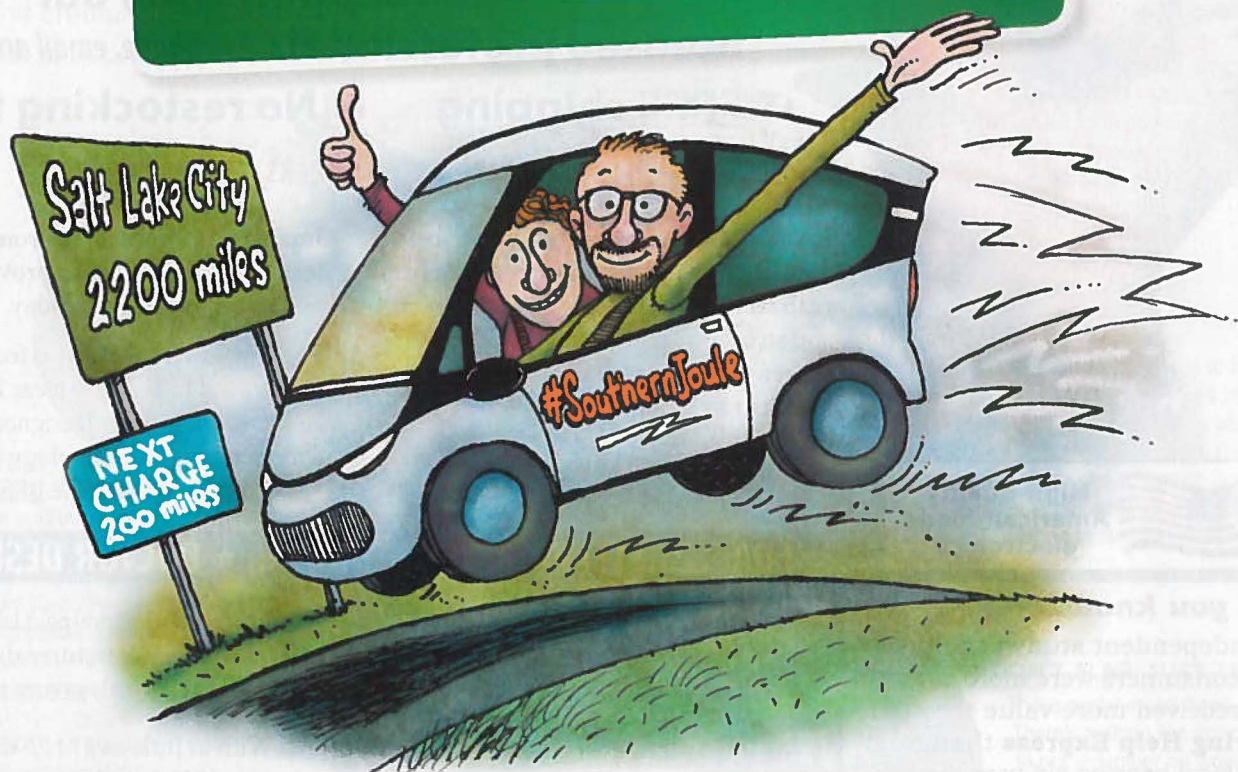


Driving the distance

CHARGING ACROSS AMERICA IN AN ELECTRIC CAR

BY MIKE SMITH



In late 2010, the electric cooperative I worked for wanted to evaluate and understand the evolving electric car market.

The Chevy Volt and Nissan Leaf, the first of a new generation of mass-produced electric vehicles (EVs), were hitting the road, and we purchased one of each to study what they would mean to electric cooperatives and our members. Both cars were competent, with each offering a different driving experience. The Chevy Volt used a gasoline engine to significantly extend the range of the car. The all-electric range was 35 miles. The gasoline engine would then take the car another 340 miles, at which time you needed to either plug in, fill up or both.

The Nissan Leaf was an all-electric car with a range of 84 miles on a charge—perfect for trips around town, but on longer drives, “range anxiety,” or the fear of running out of energy before arriving at a destination, was a real concern. Fully

recharging the car from a standard 120-volt electric outlet meant parking the vehicle for 12 to 20 hours at a time.

Today, just eight years later, nearly every major auto manufacturer offers a plug-in electric vehicle or has plans to roll one out. Range anxiety has downgraded to “range frustration,” as newer all-electric cars can travel much farther on a charge and there is a growing (but incomplete) network of public charging stations allowing drivers to top off their batteries faster than ever before.

Buyer beware

In February of this year, as part of a new e-mobility research project for the statewide association of electric cooperatives, we purchased a gently used 2017 Chevy Bolt with a range of 238 miles on a single charge.

One fact became clear at the start of the buying process:

Dealers still don't fully understand how electric cars work or how to advise buyers on the important topic of charging.

EV owners quickly learn the difference between Level 1 (slow), Level 2 (faster), and DCFC or DC fast chargers (fastest). Even with the fast-charging option, EVs take a relatively long time to refuel when compared to gasoline vehicles. Adding 150 miles of range to a Chevy Bolt takes about an hour on a DCFC and 6.5 hours on a Level 2 charger. And if you are thinking about using the 120-volt wall outlet your computer is plugged into, that Level 1 charge will take more than 30 hours.

DCFC capability is something most people don't think about until they own an electric car and attempt to take a long trip. In our search for a Chevy Bolt, more than half of the cars we found did not have the DCFC port (a \$750 upgrade)—a serious shortcoming for a car that relies exclusively on electricity for fuel.

Road trip to Atlanta

In March, I put the Bolt to the test on a road trip from Columbia to Atlanta. Each 210-mile leg was theoretically within the maximum range of a single charge on this car, but I knew that highway speeds of 70-plus miles per hour would decrease that range, especially with the heating and air system in use.

On long-distance trips, EV owners need to understand what charging options are available along their route, and how long it will take to charge at each one. As of this writing, there is no one source for this information. I planned my Atlanta trip using five different smartphone apps, each with different maps, listings and information on charging stations.

I found the PlugShare app to be the best resource for

**ALL
CHARGED
UP** Author Mike
Smith and his Bolt
in the ECSC parking
lot, just outside Columbia.



finding chargers. This is a crowdsourced app that allows EV owners to keep each other informed on the location and operating status of charging stations. However, this app does not provide access to private charging networks.

Private charging networks across the Southeast include Greenlots, ChargePoint and EVgo. Each network has its own app that drivers use to initiate and pay for charging sessions. Tesla owners have exclusive access to an extensive national network of DCFC stations; but alas, the Supercharger network isn't open to all EVs. For my trip to Atlanta, I used the ChargePoint app to charge the Bolt at two Georgia Power DCFC stations along I-20.

Using a DCFC charging station is not the same as pulling up to a traditional gas station. Currently most public charging stations have a single fast charger, and if it is occupied, you will have to wait. If the charger is down, a problem I encountered on my first stop, you either move on to the next station (assuming you have enough juice) or default to a much slower Level 2 charger if one is available on-site.

On my trip, I budgeted two additional hours of travel time—and just barely made it for a 1 p.m. meeting. When the DCFC at my first stop in Thomson, Georgia, was out of order, I plugged into a Level 2 charger for 57 minutes to get an extra 20 miles of range and continued on. At the next charging station in Madison, Georgia, using a working DCFC unit, it took 50 minutes to add 103 miles of range.

Next stop: Salt Lake City

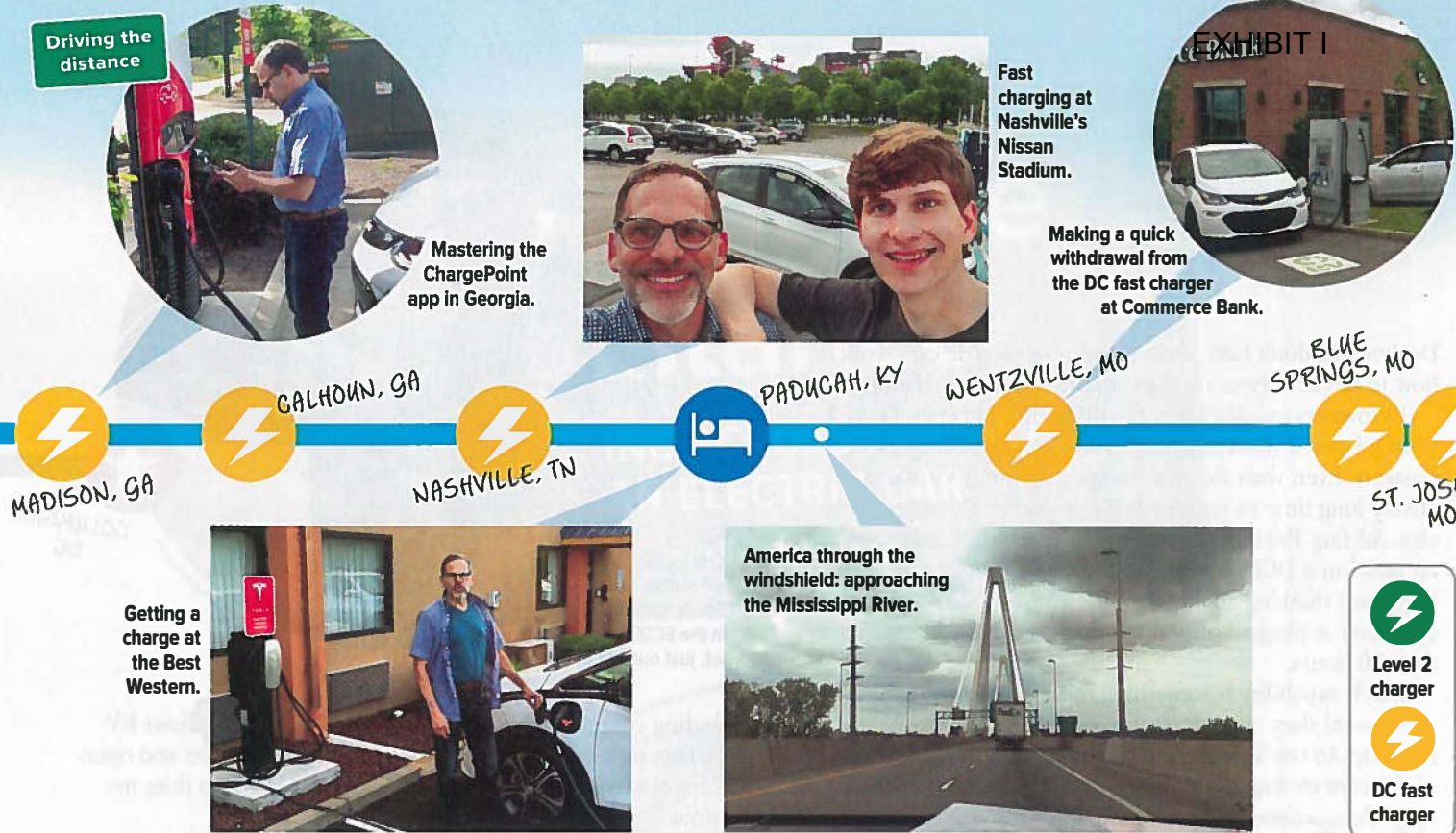
After getting additional experience driving and charging the Bolt on short trips, I wondered what it would be like to plan a longer journey requiring multiple stops over many days. That opportunity came sooner than expected with a challenge issued by Touchstone Energy to cooperatives across the nation: Drive your co-op's electric car to the 2018 Connect Conference EV workshop in Salt Lake City.

The Drive to Connect Event drew five other teams hailing from Oklahoma, Colorado, Montana, Minnesota and Georgia.

Understanding EV chargers

How long does it take to charge an electric car? The answer depends on the type of charger, its capacity and the car's maximum charging capacity—both measured in kilowatts.

CHARGER TYPE	VOLTAGE	CAPACITY	MINUTES TO ADD 80 MILES OF RANGE
Level 1	120	1.4 to 1.9 kw	824 @ 1.4 kw 630 @ 1.9 kw
Level 2	240	3.4 to 20 kw	350 @ 3.4 kw 60 @ 20 kw
DC fast charger	480	50 to 400 kw	24 @ 50 kw 3 @ 400 kw



In early May, with my 16-year-old son, Colin, along for the ride, we joined a fleet of electric cars converging on Utah—two Teslas (a Model S and Model 3), two Chevy Bolts, a Prius Prime, and a Ford Fusion. Along the way, we planned to post trip reports on social media. At the end of the rally, we would all share data and lessons learned.

Our team, called Southern Joule (#SouthernJoule on Twitter), planned for the 2,200-mile journey by using a good old-fashioned *Rand McNally Road Atlas*, Google Maps and the PlugShare Trip Planner, which gave us a baseline of the chargers available on each possible route.

Immediately, we were struck by the scarcity of DCFCs on the first half of our trip and the absolute lack of DCFCs—or even Level 2 chargers—through parts of the Midwest. We'd have to improvise by bringing charging gear that would allow us to refuel the Bolt from 240-volt, 50-amp outlets at RV campgrounds and the occasional 240-volt, 30-amp dryer outlet. After careful review, the route we chose called for a five-day journey that included a 24-hour window for unexpected delays.

On the road

We left Columbia before dawn, following I-20 to Atlanta and I-75 to Chattanooga then I-24 through Nashville with plans to stop for the night in Paducah, Kentucky, at a Best Western with a Level 2 charger.

We were behind schedule almost immediately, thanks to interrupted charging sessions in Georgia and Tennessee, the most frustrating glitch taking place at Nissan Stadium in Nashville. We were hungry and looking to stretch our legs when we plugged into a DCFC at the foot of the John

Seigenthaler Pedestrian Bridge and walked across the Cumberland River into downtown Nashville in search of great food and music.

Unfortunately, just before our meal started, I had to run back across the bridge to restart our charging session. The network that operates the station limits charging time to 45 minutes. We needed almost 90 minutes to top off the Bolt. To start the second charging session, I had to physically disconnect and reconnect the charging plug.

We still had another 130 miles to go to Paducah for the night, so we got back on the road as soon as we finished eating—no time for sightseeing. We made it to Paducah, plugged in the car and crashed.

Day 2 was uneventful as we drove 600 miles through Illinois and Missouri to our next scheduled overnight stop at the Wunder Roost B&B outside of Lincoln, Nebraska. The PlugShare app indicated the inn was EV-friendly. Before we left South Carolina, I called to confirm, and the owners shared they had installed a camper-friendly 240-volt, 50-amp outlet four years ago for a frequent guest who drives up from Dallas twice a year in his Tesla.

There weren't a lot of dedicated charging stations in Missouri, but we found enough DC fast chargers to make it work, and we explored several small towns during one-to-two-hour charging sessions at the Commerce Bank in Wentzville, a strip mall in Blue Springs, and the St. Joseph Hy-Vee Supermarket. We did not arrive at Wunder Roost until after midnight, but owner Jim Wunderlich showed us to the plug and we started charging for the night.

Day 3 started with a surprise. The guest with the Tesla had



Working on the trip log in Nebraska.

A quiet night charging at the Ogallala police station.



Topping off at the prettiest charging station on the trip.

EXHIBIT I

ROGA, NE



LEXINGTON, NE



OGALLALA, NE



OVID, CO

CHEYENNE, WY



RAWLINS, WY



The Tesla waits its turn at the Wunder Roost B&B.

Commandeering the dryer outlet at the Hip House Airbnb.



Hypermiling over the mountains to a charge and a few hours' rest.

arrived early that morning and was patiently awaiting his turn at the plug. Jerry Jorgensen has been a Tesla Model S owner since 2014, and he shared his experience and advice as a dedicated EV owner familiar with the challenges of long-distance travel.

With limited charging options on our next leg, Day 3 began a cycle of driving and charging "where night and day got mixed up," as Colin described it. Up until this point, we had used fast charging during the day and slower Level 2 charging at night while we slept. Now, we had to follow a pattern of driving 125 to 200 miles at a time to reach the next charging station, wait between four and nine hours per stop to get an

adequate charge, then immediately hit the road again.

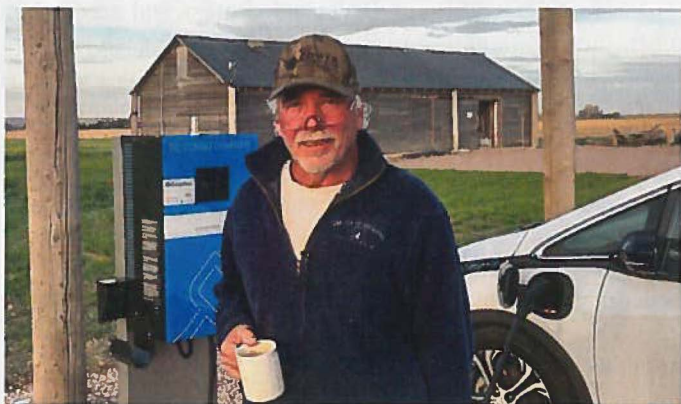
We planned to make Cheyenne, Wyoming, that night. We had reservations at an Airbnb home that said we were welcome to use their dryer plug to charge the Bolt while we slept, but we only made it as far as Ogallala, Nebraska, arriving just before midnight. Fortunately, the Ogallala charger was free, located at the town's police station and one of the fastest Level 2 chargers we encountered. I set my alarm for 4 a.m. and we slept in the car.

Unexpected detour

When the alarm went off signaling the start of Day 4, we left for Cheyenne. Our plan called for taking I-80 through Nebraska, Wyoming and into Utah all the way to Salt Lake City, but a wrong turn put us on I-76 to Denver. As we mapped our way back to our planned route, an interesting DCFC popped up on the PlugShare website and we made a short detour to check it out.

We arrived at Wind Orchard Energy outside of Ovid, Colorado, just before sunrise. This charging station, powered in part by its own windmill, is located seemingly in the middle of nowhere, but convenient to I-80 and I-76. Modeled after a roadside farmer's market and surrounded by lush, green farmland near the convergence of the North and South Platte rivers, Wind Orchard was the prettiest charging station on the trip.

Colin and I stopped to take a few pictures and top off the car, and it wasn't long before owner Jeff Hebert came out to greet us. Hebert installed this station three years ago as part of a vision to support electric vehicles. He allows drivers to charge for free, and was shocked when it took two years



AHEAD OF THE CURVE Jeff Hebert, owner of the Wind Orchard Energy DCFC outside Ovid, Colorado, is surprised that co-ops and utilities in rural America haven't built their own networks of fast-charging stations. "You guys are in the energy business," he says. "I think you ought to have one of these on the base of every pole. That would solve range anxiety."

PARK CITY, UT

SALT LAKE CITY, UT



PHOTO COURTESY OF MIKE SMITH

WE'RE HERE!

Colin and Mike
roll into Salt Lake City.

AT A GLANCE

Almost 2,200 miles
40 hours of drive time
54 hours plugged in
512 kilowatt-hours used (equivalent to 142 mpg)
\$186 spent on charging

before the first car showed up, a Chevy Bolt driving through from New York.

We rolled into Cheyenne at 9:30 a.m., more than 12 hours late for our Airbnb reservation, but Christine and Steve Johnson didn't seem to mind. We had arranged in advance to use their 240-volt dryer outlet to charge the car but doing so required us to move furniture and pull off the outside dryer vent in order to run the cord through the opening. To say they were accommodating would be an understatement. Luckily, we brought everything we needed to make this charging stop work, including tools, adapters and a heavy-duty 50-foot extension cord.

Both Colin and I got some sleep, and before we left at 6:30 p.m. that evening, I was able to catch up on our trip log, while Colin, an amateur beekeeper, spent the afternoon with the Johnsons inspecting their hives.

Over the mountain

We left Cheyenne rested and fully recharged for the toughest leg of the trip. We had almost 500 miles to cover and no dedicated charging stations until Park City, Utah, just outside of Salt Lake City. We'd have to make do at RV campgrounds scattered along the way, but first we had to climb the 8,000-foot Sherman Summit, the highest spot on I-80, driving into potentially strong headwinds.

This was the part of the trip that taught us how to hyper-mile in an electric vehicle. We drove slower than traffic, with no AC or heat and the windows up. We drove with the elevation changes, going much slower uphill and coasting down.

It worked. When we made our first stop later that night at the Red Desert Rose Campground in Rawlins, Wyoming, we had driven 160 miles and the battery was still half-charged, meaning we had achieved an effective range of 320 miles—amazing fuel efficiency.

After charging at the campground overnight, we left at 5 a.m. to cross the rest of Wyoming. We drove the 266 miles to Park City, Utah, our longest leg on a single charge, without stopping to refuel. Park City is less than 30 miles from Salt Lake City, and the drive down is an elevation drop of almost

3,000 feet. There was still enough juice in the batteries to make it, but we needed a break and the DCFC at the Park City Library was free.

At the EV workshop the following day, I presented our results. Door to door, our trip covered almost 2,200 miles and took nearly 100 hours total—40 hours behind the wheel and 54 hours plugged in to recharge the batteries. The price of energy varied greatly, from free at some locations to more than \$2 per kilowatt-hour during one charging session. Our total charging bill for the trip from Columbia: \$186.

We used 512 kilowatt-hours of electricity on the journey to Salt Lake City, or the same amount of energy contained in 15 gallons of gasoline, giving us an efficiency rating of 142 MPGe. That earned Southern Joule recognition at the conference for both the farthest distance traveled and the best fuel economy.

Lessons learned

Electric vehicles are here. The cars themselves are comfortable, reliable, well-built and roadworthy, but they have raced ahead of the sales and charging infrastructure—at least for now.

One of the most interesting reports from the workshop illustrates the potential for what the EV infrastructure can be. The Minnesota team, Road Trip Recharged, drove a Tesla Model S sedan 1,200 miles to Salt Lake City, taking advantage of Tesla's extensive Supercharger network and the car's integrated software. Drivers Amanda Groethe and Whitney Ditlevson didn't have to plan their charging stops—the car's navigation system told them when and where they needed to go, and exactly how much time it would take to charge the vehicle at each location.

For Southern Joule, we knew our trip to Salt Lake would take a long time. We expected the unexpected, we planned our journey and made sure there was room for unscheduled stops and delayed charging sessions. We treated the trip like an adventure, but a time will come in the not-too-distant future when a reliable, national network of charging stations will make long-distance trips by EV a routine endeavor. As that network takes shape, electric cooperatives will play a pivotal role in powering charging stations in rural and suburban communities across the nation. ☺

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